EMMENANTHE PENDULIFLORA (HYDROPHYLLACEAE): FURTHER CONSIDERATION OF GERMINATION RESPONSE

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Abstract

Scarification of seeds as well as the presence of burned remains of *Adenostoma fasciculatum* can serve as germination triggers for the post-fire annual herb *Emmenanthe penduliflora* in the chaparral of southern California. Seeds from desert populations of *E. penduliflora* respond primarily to scarification. Such germination mechanisms may be an evolutionary response to the differing frequency of fire in these two ecosystems.

Emmenanthe penduliflora Benth. (Hydrophyllaceae) is a common annual herb that germinates abundantly in the chaparral only during the first years after fire (Horton and Kraebel, 1955; Christensen and Muller, 1975). Various mechanisms have been postulated to explain this common post-fire response: heat shock stimulation, seed coat scarification and/or the removal of germination inhibiting substances from the soil (Sweeney, 1956; Muller et al., 1968). Fire may act to scarify seed coats and enable the seeds to imbibe water; however, Sweeney (1956) has shown that *E. penduliflora* seeds imbibe water without scarification but still require mechanical scarification for germination. Whereas washings from live foliage of *Adenostoma fasciculatum* have been shown to inhibit the germination of several herbaceous species, Christensen and Muller (1975) were not able to show a definite inhibitory effect of leachate on germination of seeds of *E. penduliflora*. Wicklow(1977) obtained only 1 percent germination of *E. penduliflora* under control conditions and in the presence of living stem segments of *A. fasciculatum*; however, when partially-ashed stem segments were added to petri dishes containing seeds on chaparral or potting soil, up to 49 percent germination was observed. He was able to extend these findings to the field where *E. penduliflora* commonly appeared in chaparral plots that had been clear-cut but spread with burned brush remains, or burned and the brush remains left in place. Only occasional *E. penduliflora* plants were seen on clear-cut zones that did not receive burned plant remains and no plants were seen in the undisturbed chaparral control area. Wicklow suggested that the ger-

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mination trigger in *E. penduliflora* may involve the "interaction between burned plant remains and certain components of the soil or soil microflora" (1977, p. 204).

In this study our first objective was to attempt to confirm the laboratory results obtained by Wicklow in chaparral populations. Also, because *E. penduliflora* occurs in deserts of creosote bush (*Larrea tridentata*) scrub (Burk, 1977) that rarely if ever experience fire, we examined the germination of seeds from a desert population of *E. penduliflora*. We know of no attempt to differentiate populations of this species at a subspecific level (e.g., Munz, 1974).

Methods

Seeds of *Emmenanthe penduliflora* from a coastal chaparral population were collected on 18 Jun 1979 from the Santa Monica Mountains, Los Angeles County. The site was a west-facing slope dominated by *Adenostoma fasciculatum* at an elevation of 350 m, 5 km south of Highway 101 along Decker Road. This area was part of 10,300 ha that burned the previous October. Branches of *A. fasciculatum* for use in germination tests were collected on the same date from a 14-year-old stand in the Santa Ynez Mountains.

Seeds from a desert population were collected on 2 Jun 1979 in the Eagle Mountains of Riverside County, about 7.2 km northwest of Desert Center and more than 100 km east of the chaparral-desert transition in southern California. Seeds were gathered from *E. penduliflora* growing beneath *Olneya tesota* along a wash that traversed a southeast-facing slope dominated by *Larrea tridentata*. Branches of live and dead *O. tesota* less than 20 mm diameter were also collected here. At this site there was no evidence of fires, including campfires.

Methods of Wicklow (1977) were followed as closely as possible throughout this experiment; only specific details are elaborated here. Whatman #42 ashless filter paper or unwashed soils, sieved to pass 2-mm mesh, were placed in 5-cm diameter plastic petri dishes. Shrub stems were then added as an additional experimental treatment. There were four replicate dishes of each combination of substrate and shrub stem, each dish with 25 seeds (Table 1). Seeds of the scarified treatment received a shallow scratch running the length of the seed. All seeds were incubated for 30 days at 10°C with 12-hour light and dark periods provided by cool-white fluorescent lights. They were then moved to a growth chamber at 25°C, with 12-hour light and dark periods provided by both incandescent and fluorescent bulbs. Through the entire period of incubation, the contents of the dishes were kept moist by the addition of glass-distilled water. At weekly intervals the segments of stems in each dish were haphazardly rearranged. The final germination count was made after 10 days of incubation at 25°C.

TABLE 1. EFFECTS OF SCARIFICATION, PLANT PARTS, AND SOIL ON THE GERMINATION OF *E. penduliflora*. The data are percent germination, the mean of four replicate petri dishes per treatment. (** = $p < 0.05$ in one-tailed t-test for significant increase in germination over control; * = $p < 0.10$.)

			Non-scarified with stem segments			
			Adenostoma			
					Partially-ashed	
	Scarified	Non-scarified	Living	Ashed	This study	Wicklow
Chaparral seeds						
Filter paper	69**	0	1	0	57**	0
Potting soil	31**	0	1	2	32**	49
Chaparral soil (unburned)	11**	3	3	3	18**	33
			Olneya		*Adenostoma*	
			Living	Dead	Partially-ashed	
Desert seeds						
Filter paper	55**	2	1	1	7*	
Potting soil	29**	0	1	1	11*	
Desert soil	39**	0	1	2	6	

RESULTS AND DISCUSSION

Results of the germination experiments are shown in Table 1. Germination of scarified seeds was observed within 1 week at 10°C; after 30 days at 10°C, up to 62 percent of scarified seeds germinated. The response of our seeds to this treatment confirmed viability of the seeds we tested.

The results support Wicklow (1977) in showing an increased germination response over controls when chaparral seeds of *E. penduliflora* were placed in the presence of partially-ashed stem segments of *A. fasciculatum* (Table 1). Unlike the results of Wicklow, however, our most significant response in all treatments was observed with filter paper; 57 percent of the chaparral seeds germinated on filter paper with partially-ashed stems of *A. fasciculatum*. Therefore, Wicklow's suggestion that germination is triggered by an interaction between soil and burned plant remains was not supported. In fact, our weakest response of chaparral seeds in both scarified and partially-ashed stem treatments occurred on chaparral soil collected from unburned stands. Perhaps this was the result of substances inhibitory to germination still present in the soil.

Wicklow (1977) suggested that burned stem segments of *A. fasciculatum* might absorb a germination inhibitor from the seeds; however, he found that leaching *E. penduliflora* seeds for 24–48 hours in running water did not increase germination. Also, he was not able to increase germination by incubating the seeds on filter paper with activated charcoal.

We also noted a slight response of desert seeds to added stem segments of partially-ashed *A. fasciculatum* and a high response of these seeds to scarification. This difference in response between seeds collected from chaparral and desert populations implies slight ecotypic differences between these populations in mechanisms of germination. Scarification may occur commonly in the desert where coarse soils and wind-driven sheet erosion may scratch many seeds. Differences in the sizes of the seeds were also noted; desert seeds were significantly longer (2.46 mm ± 0.06 s.e. vs. 1.70 mm ± 0.04; $t = 10.1$, $n = 20$, $p < 0.05$) and heavier (0.796 mg ± 0.02 vs. 0.449 mg ± 0.02; $t = 12.0$, $n = 30$, $p < 0.05$) than chaparral seeds.

The results of this experiment confirm Wicklow's (1977) suggestion of a germination trigger present in partially-ashed stem segments of *A. fasciculatum* for populations of *E. penduliflora* in chaparral, an ecosystem with relatively frequent fires. However, in desert areas it appears that seeds depend more on scarification to trigger germination. The differences in germination mechanisms may indicate an evolutionary response to differing frequencies of fire in these two ecosystems.

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